Mega Lake Maitland Pty Ltd

Lake Maitland

Interim Stygofauna Report: January 2007 – August 2010 Results

February 2011

FINAL

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Interim Stygofauna Report: January 2007 – August 2010 Results

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Executive Summary

The Lake Maitland Uranium Project (LMUP), owned by Mega Lake Maitland Pty Ltd (Mega), is located approximately 130 km south-east of Wiluna in the eastern Goldfields of Western Australia. This interim report collates information on the stygofauna sampling programme that has been undertaken between January 2007 and August 2010, and is ongoing. The overall objective of this assessment is to gather sufficient information to show that the stygofauna within the LMUP area are not at risk from the mine proposal.

Stygofauna (groundwater fauna) occur in various types of aquifers which exhibit voids of a sufficient size for biological requirements. They also require suitable groundwater quality, with two key factors limiting distribution being pH and salinity. Sites sampled between 2007 and 2010 exhibited circumneutral to alkaline pH and variable salinity concentrations. Salinity increased closer to the Lake Maitland playa, and at some sites was considered restrictive to stygal communities.

Groundwater quality and habitat characteristics led to the highest diversity of stygofauna being found on the edge of the playa and within calcareous habitats. To date, 29 stygal or putative taxa have been found, equating to over 600 specimens. Over half of the taxa are currently considered to be restricted to the LMUP area.

Future work will focus of determining those taxa at risk once impacts related to the LMUP including the drawdown zone and mine developmental impacts have been finalised. This will aid in classifying sites within reference and impact zones. Further collation and analysis of the LMUP results may also warrant further sampling (particularly within the calcrete tongue and borefield areas) or potential molecular analysis of some specimens.

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1. INTRODUCTION

1.1 Project Background

The Lake Maitland Uranium Project (LMUP), owned by Mega Lake Maitland Pty Ltd (Mega), is located approximately 130 km south-east of Wiluna in the eastern Goldfields of Western Australia. Mega proposes to develop the Lake Maitland uranium deposit on the Barwidgee Pastoral Station (Mining Lease M35/1089) (**Figure 1**). The proposal falls under the jurisdiction of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Of the seven matters of national environmental significance which require federal Ministerial approval, two were identified for the LMUP; '*nuclear action*' and '*listed threatened species and ecological communities'*. The Environmental Protection Authority (EPA) has set the level of assessment for the LMUP as an Environmental Review and Management Programme (ERMP). Therefore the LMUP will continue through the EPBC Act assessment process as a controlled action. Stygofauna assessment forms one component of the environmental studies currently being undertaken for the LMUP. This interim report collates information on the stygofauna sampling programme that has been undertaken between January 2007 and August 2010, and is ongoing.

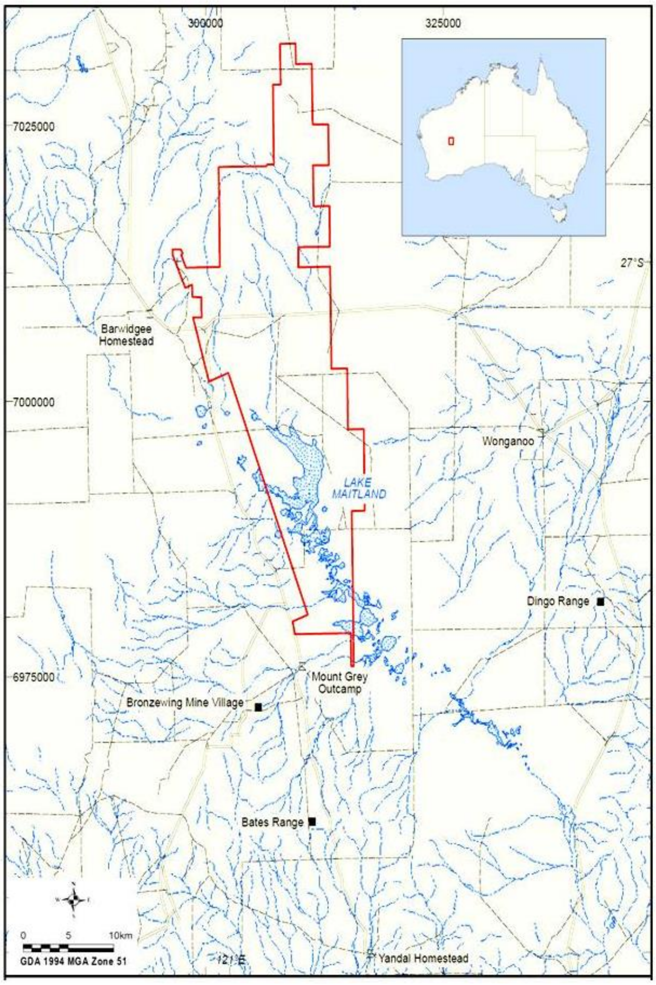

Figure 1: Location of the Lake Maitland Uranium Project area (tenement outlined red).

1.2 Physical Environment

1.2.1 Biogeographical Region

The Interim Biogeographic Regionalisation for Australia (IBRA) is a bioregional framework which divides Australia into 85 bioregions and 403 subregions on the basis of climate, geology, landforms, vegetation and fauna. It was developed through collaboration between state and territory conservation agencies with coordination by the Department of Sustainability Environment Water Population and Communities (Department of Sustainability Environment Water Population and Communities 2010).

As defined by IBRA, the Project area is located in the Eastern Murchison subregion of the Murchison Bioregion (**Figure 2**). This subregion consists of extensive areas of elevated red/red-brown desert sandplains with minimal dune development, breakaway complexes and internal drainage and salt lake systems associated with the occluded Palaeodrainage system. Mulga woodlands dominate the subregion, as well as hummock grasslands, saltbush shrublands and *Tecticornia* (samphire) shrublands (Cowan 2001).

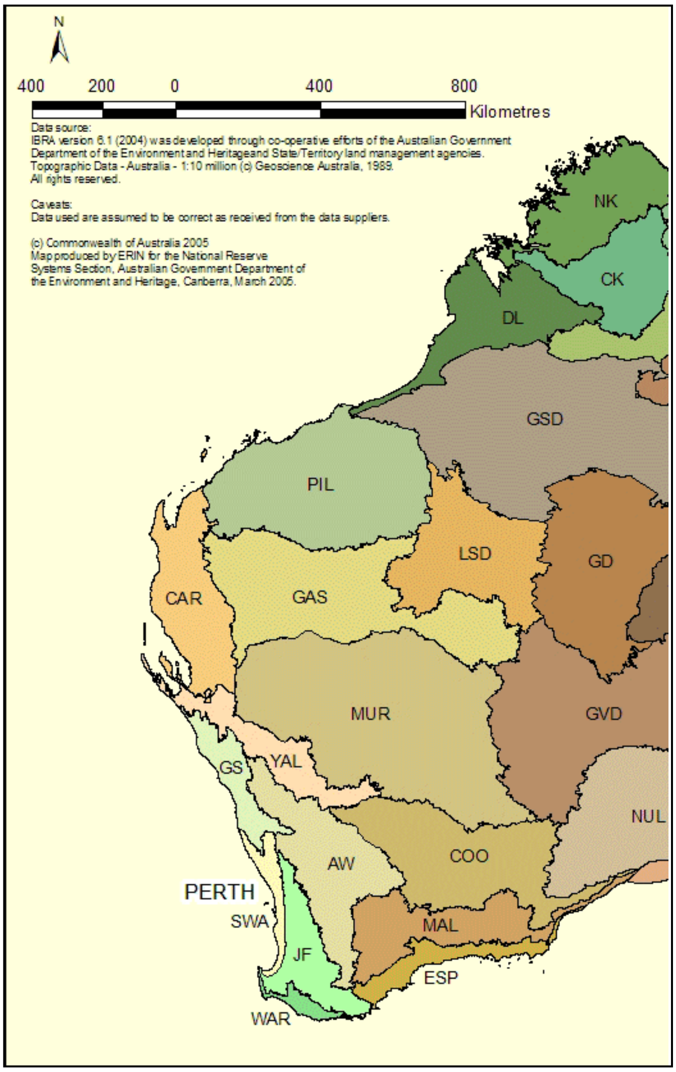

Figure 2: Location of the Project within the Eastern Murchison (MUR) subregion.

1.2.2 Climate

The Murchison region is characterised as having an arid climate, with an annual rainfall of approximately 200 millimetres (mm). The area has a bimodal rainfall distribution, with both summer and winter rain (Beard 1990, Gilligan 1994). Summer weather is influenced by anti-cyclonic systems to the south-east, creating a pattern of clear skies and easterly winds. The region borders the southern end of the Intertropic Convergence Zone and, as a result, thunderstorm activity and summer rainfall is generated. The anti-cyclonic system also directly influences winter weather patterns, generating westerly winds and rain-bearing frontal systems (Gilligan 1994).

The nearest Bureau of Meteorology (BOM) weather station to the LMUP is located in Wiluna, approximately 15 km to the north-west. Wiluna experiences hot dry summers and mild dry winters with irregular rainfall averaging 256 mm per annum. The majority of rainfall occurs between January and June (**Figure 3**), resulting from summer cyclonic rains and isolated thunderstorms. Average maximum temperatures range from 19.4 °C in July to 37.9° C in January. The average minimum temperatures follow a similar pattern, ranging from 5.4 °C in July to 22.8 °C in January (BOM 2010).

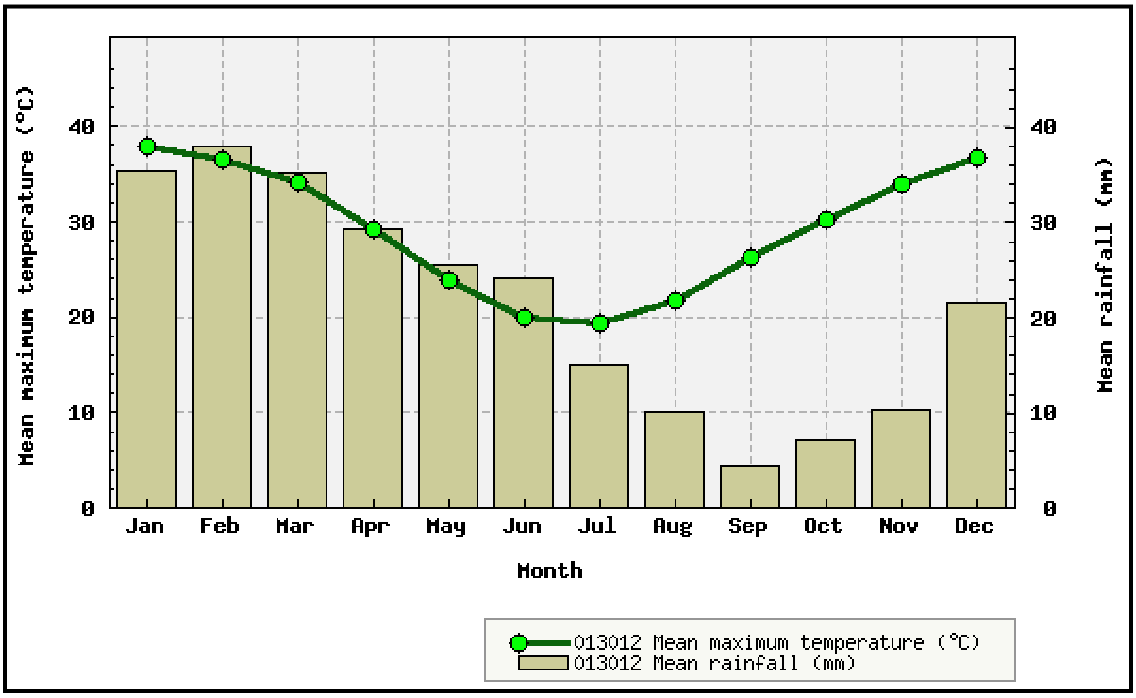

Figure 3: Average monthly rainfall and temperatures recorded for the Wiluna weather station (BOM 2010).

1.2.3 Regional Hydrogeology

There are four main groundwater aquifer types associated within the region in which the LMUP area occurs:

- Alluvium: unconfined surficial aquifers, potentially representing substantial sources of groundwater. Waters are generally of low salinity and are predominantly used for pastoral purposes.
- Calcrete: the secondary porosity and high permeability of calcrete can result in the formation of locally high-yielding aquifers. Groundwater salinity is typically brackish to saline.
- Palaeochannel sand: these aquifers are commonly overlain by a confining kaolinitic clay layer which can extend to depths of 80 m. They represent the most important aquifers in the region, reaching up to 1 km wide and 40 m thick in the trunk palaeochannels. The groundwater is generally hypersaline and is therefore mostly used for mining activities.
- Fractured rock: these aquifers are associated with rocks such as greenstones, granitoids and minor intrusives which display secondary porosity and permeability, resulting from faults, fractures and weathering (Johnson *et al.* 1999).

1.3 Stygofauna

Stygofauna (groundwater fauna) are predominantly comprised of invertebrates. Crustaceans generally dominate stygal communities with other groups including worms, insects, gastropods and water mites occurring to a lesser extent. They can be further classified according to their level of dependency on the subterranean environment. Invertebrates that enter groundwaters passively or accidentally are referred to as stygoxenes, while those that inhabit groundwaters on a permanent or temporary basis are called stygophiles. It is only animals that are obligate groundwater dwellers that are termed stygobites. Stygobites are restricted to their subterranean environment and can be distinguished from surface dwelling animals ecologically and genetically (Cooper *et al.* 2002, Danielopol and Pospisil 2000). They display characteristics typical of a subterranean existence which include: a reduction or absence of pigmentation, absence or reduction of eyes, and the presence of extended locomotory and sensory appendages (Humphreys 2008).

Stygofauna occur in various types of aquifers which exhibit voids of a suitable size for biological requirements (Humphreys 2008). In Australia, increased research efforts and improved sampling techniques have demonstrated an increasingly rich stygal community. Previously believed to be restricted to karst landscapes, obligate groundwater inhabitants have now been found in alluvial sediments, fractured rock aquifers, pisolites and thin regoliths (Humphreys 2006, Humphreys 2008). In Western Australia, studies have shown that the calcretes and alluvial aquifers of the arid and semi-arid zones contain rich stygofaunal communities, with the Pilbara and to a lesser extent the Yilgarn, standing out as global hotspots for stygofauna diversity (Environmental Protection Authority 2007).

Diverse stygofauna assemblages associated with calcrete systems in the northern Yilgarn region of Western Australia have been well documented with molecular and morphological investigations revealing that each calcrete can host many endemic species, acting as a 'calcrete island' (Cooper *et al.* 2007, Cooper *et al.* 2002, Guzik *et al.* 2008, Humphreys 2006, Humphreys 2008, Humphreys and Adams 2001, Leys *et al.* 2003, Watts and Humphreys 1999, 2000, 2001, Watts and Humphreys 2003). Because of the demonstrated restricted distributions of many stygofauna taxa to a single calcrete system, 34 calcrete systems in the Goldfields have been listed as Priority 1 Ecological Communities (PEC) including six calcretes in the northern Carey palaeodrainage channel in and near the LMUP.

1.3.1 Risks and Relevant Legislation

In relation to mining, potential threats to subterranean ecosystems, which may support stygofauna and/or troglofauna communities, include:

- lowering the water table, which may dry out subterranean habitats;
- altering the water quality, which may exceed species tolerance limits; and
- direct removal or disturbance to habitats (Environmental Protection Authority 2003).

Subterranean fauna are protected under State and Federal legislation are protected under the same legislation as that of terrestrial fauna, and are governed under three acts:

- *Wildlife Conservation Act 1950 (WA)*;
- *Environmental Protection Act 1986 (WA)*; and
- *Environment Protection and Biodiversity Conservation Act 1999 (Cth)*.

With the legislation in mind, the Environmental Protection Authority (EPA) developed:

- *Guidance Statement No. 54: Consideration of Subterranean Fauna in Groundwater and Caves During Environmental Impact Assessment in Western Australia* (2003); and
- *Guidance Statement No. 54a Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia (Technical Appendix to Guidance Statement 54)* (2007).

These documents provide advice to proponents and the public on the EPA's minimum requirements for environmental impact assessment (EIA) and management of subterranean fauna.

Mining proposals that will potentially impact on groundwater or habitats that support subterranean fauna require a risk assessment to ensure mining operations do not threaten the viability of significant taxa. Proponents must demonstrate that any threatened species within the potential impact zone also occur outside this area. For taxa restricted to the impact zone, a suitable management plan must be developed, which includes ongoing monitoring of subterranean fauna, ensuring the persistence of species (Environmental Protection Authority 2003).

1.4 Scope and Objective of Report

The overall objective of the Lake Maitland stygofauna assessment is to gather sufficient information to show that the stygofauna within the LMUP area are not at risk from the mine proposal. A further objective is to allow for the implementation of appropriate management tools to ensure the viability of the stygal communities.

This report provides an interim summary of the stygofauna sampling effort and the stygal and putative stygal taxa identified from the groundwaters of LMUP area to date (January 2007 - August 2010). It follows the October 2010 interim summary (Outback Ecology 2010) and earlier baseline report (Outback Ecology 2007), to fulfil in part the primary objectives for the LMUP stygofauna assessment.

2. SURVEY DESIGN AND SAMPLING EFFORT

A total of 88 stygofauna samples from 62 bores and pastoral wells (sites) have been collected over five separate surveys of the LMUP area (**Table 1**). Sites are situated within a range of habitat types throughout the LMUP, including calcrete, floodplain and playa regions (**Figure 4**). The number of samples collected to date exceeds the 40 samples recommended by EPA Guidance Statement 54a (2007) for areas which are likely to be impacted by a proposal. However, without the final drawdown and mine development footprints, these sites cannot be assigned as impact and reference at this stage.

Table 1: Sampling effort and bore details for Lake Maitland stygofauna surveys, January 2007 to August 2010 (GPS coordinates presented in UTM WGS:84: 51 J). Green shading denotes a sampling event, IBD = internal bore diameter and EoH= end of hole.

Bore Code	GPS Coordinates		Survey					Bore Casing	IBD (mm)	EoH (mbgl)
	Easting	Northing	Jan-07	May-07	Dec-08	Mar-10	Aug-10			
LMAC0008	309784	6991975						PVC	80	9.0
LMAC0009	309844	6991983						PVC	83	9.0
LMAC0010	309897	6991980						PVC	80	9.0
LMAC0011	309945	6991984						PVC	83	9.0
LMAC0012	309998	6991982						PVC	83	9.0
LMAC0147	309894	6992778						PVC	83	9.0
LMAC0160	308902	6993181						PVC	83	9.0
LMAC0168	309445	6992382						PVC	83	9.0
LMAC0179	310547	6992379						PVC	83	9.0
LMAC0212	311601	6993184						PVC	83	9.0
LMAC0266	311798	6994380						PVC	83	7.0
LMAC0291	309298	6994580						PVC	83	7.0
LMAC0312	310999	6994782						PVC	83	7.0
LMAC0334	311703	6995182						PVC	83	7.0
LMAC0352	309905	6995181						PVC	83	7.0
LMAC0399	311396	6996779						PVC	83	7.0
LMAC0401	311602	6996780						PVC	83	7.0
LMAC0406	311603	6996980						PVC	83	7.0
LMAC0423	308501	6995978						PVC	83	7.0
LMAC0448	307503	6996986						PVC	83	9.0
LMAC0505	309008	6993184						PVC	83	9.0
LMAC0527	310603	6993579						PVC	80	9.0
LMAC0541	309402	6996780						PVC	80	9.0
LMAC0545	309396	6997182						PVC	83	9.0
LMSC-021	310480	6991784						PVC	95	8.0
# 15 Well	312544	7003705						NA	NA	3.8
6 Mile Bore	307741	7008070						Logs	2000	9.0
BJP5	308581	6981024						Steel	200	30.0
Eclipse Well	316616	6975320						Logs	2000	4.0
Little Well	302211	6997164						PVC	146	9.9
LMACW1	314858	7002470						PVC	48	91.0
Northern Control Bore	313864	7002434						PVC	80	49.5

Table 1 cont.

Bore Code	GPS Coordinates		Survey					Bore Casing	IBD (mm)	EoH (mbgl)
	Easting	Northing	Jan-07	May-07	Dec-08	Mar-10	Aug-10			
Salt Well	307413	6984800						Logs	2000	6.0
Two Jacks Well	314571	6990115						Steel	113	5.0
BH01	307495	6996779						PVC	50	14.0
BH02	309414	6995393						PVC	50	13.5
BH03	311495	6995979						PVC	50	14.2
BH04	311594	6994783						PVC	50	14.1
BH05	311397	6994172						PVC	50	14.5
BH06	310886	6992779						PVC	50	14.1
BH08	309993	6992230						PVC	50	12.5
BH09	309994	6991580						PVC	50	13.4
BH10	307797	6992281						PVC	50	12.6
BH11	309948	6990980						PVC	50	12.0
EH01	308397	6991573						PVC	100	23.0
EH02	310475	6991789						PVC	100	19.0
EH03	309004	6993186						PVC	100	23.0
EH04	311393	6993367						PVC	100	16.8
EH05	310600	6994777						PVC	100	22.0
EH06	308500	6995972						PVC	100	23.0
LMST001	307400	6993767						PVC	50	12.0
LMST002	308213	6993778						PVC	50	12.0
LMST003	309812	6993785						PVC	50	12.0
LMST004	307911	6992673						PVC	50	12.0
LMST005	307109	6992680						PVC	50	12.0
LMST006	308186	6994776						PVC/steel outer	50	12.0
LMST007	307909	6995780						PVC	50	12.0
LMST008	305115	6996771						PVC	50	12.0
LMST010	306324	6995800						PVC	50	12.0
LMST011	307122	6995775						PVC	50	12.0
LMST012	305413	6994778						PVC	50	12.0
LMST014	306610	6993773						PVC	50	12.0

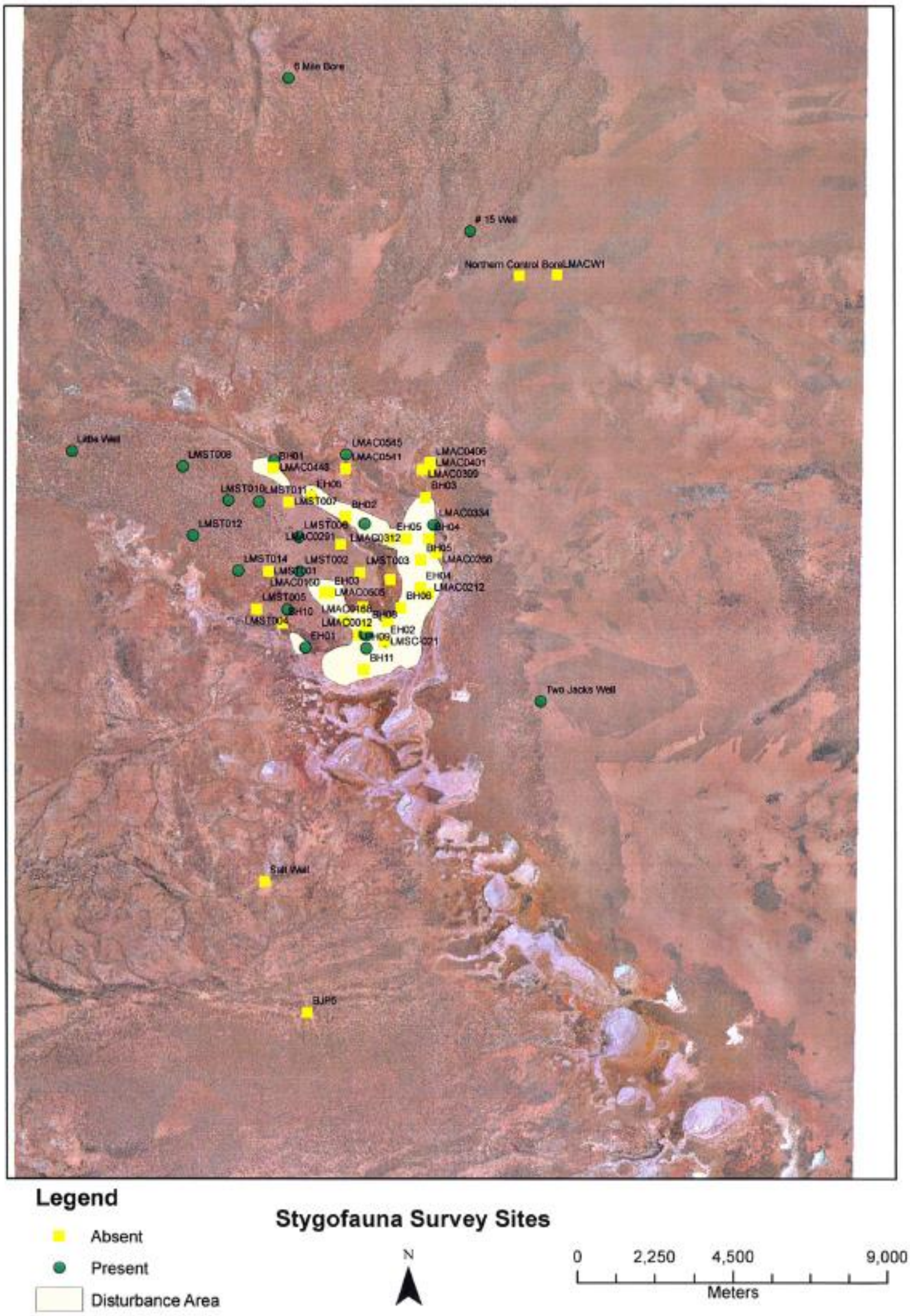

Figure 4: Map of stygofauna sites sampled between 2007 and 2010, indicating presence/absence of stygal taxa and the LMUP resource area (disturbance area).

METHODS

2.1 Groundwater Quality

Basic physicochemical data was collected during each of the sampling phases. The standing water level (SWL) (mbgl) was measured at each site using a Solinst 101 water level meter. Groundwater was then collected just below the SWL with a disposable clear PVC bailer (42 mm x 900 mm), lowered using a winch. A calibrated TPS 90 FLMV multi-parameter field instrument was used to measure the pH, temperature, salinity as electrical conductivity (EC), and dissolved oxygen (DO) of the groundwater retrieved. End of hole (EoH) was estimated for each site using the net hauls.

2.2 Stygofauna Sampling

Sampling was consistent with the procedures outlined in the EPA Draft Guidance Statement No. 54A (EPA 2007). Haul nets, found to be the most efficient retrieval method (Allford *et al.* 2008), were used during all five surveys. The sampling method was as follows:

- Samples were collected using two weighted nets with mesh sizes of 150 µm and 50 µm. Each net was fitted with a glass vial with a base mesh of 50 µm.
- The 150 µm net was lowered first to near the bottom of the hole.
- Once at the bottom the net was gently raised up and down three times to agitate the bottom sediments.
- The net was then raised slowly to minimise the ‘bow wave’ effect that may result in the loss of specimens, filtering the stygofauna from the water column on retrieval.
- Once retrieved the collection vial was removed and all the contents emptied into a 250 ml polycarbonate vial and preserved with 100% undenatured ethanol in the field.
- This process was repeated up to five times.
- The same procedure was then repeated using the 50 µm net.
- To prevent cross-contamination, all sampling equipment was washed thoroughly with Decon 90 (detergent) and then rinsed with distilled water after sampling each site.
- Samples were couriered back to Outback Ecology’s laboratory in Perth.

Licences to Take Fauna for Scientific Purposes, *Wildlife Conservation Act 1950*, Regulation 17, were obtained from the DEC for the surveys (Lic. Nos SF005819, SF006730, SF007342, SF007530). The reports accompanying the licences have been submitted to the DEC. Personnel involved in the surveys included Michael Scanlon, Andre Schmidt, Dr Erin Thomas, Bronwyn Gordon, Dr Fiona Taukulis, Dr Veronica Campagna and Nicholas Stevens from Outback Ecology, and Melissa Bolton from Mega Lake Maitland Pty Ltd.

2.3 Specimen Identification

Preserved samples were sorted manually using Leica stereomicroscopes. Sub-samples were taken for taxa which were present in high numbers. The specimens were then identified to their lowest possible taxonomic rank by Michael Scanlon, Dr Erin Thomas (ET), Dr Nihara Gunawardene (NRG) and Nicholas Stevens (NS) of Outback Ecology using stereomicroscopes and where required, compound microscopes. Assistance in sorting was provided by Richard de Lange (RD), Kimberley Moiler (KM), Syngeon Rodman (SR) and Dr Peter Langlands (PRL) of Outback Ecology.

Identifications were undertaken using available literature including published and unpublished keys and species descriptions. Specialist taxonomists were employed to obtain higher taxonomic resolution and provide peer review, where necessary. The specialists and their area of expertise are provided in **Table 2**. Undescribed taxa were assigned morphospecies names based on morphological features. Morphospecies names have also been retrospectively assigned to provisionally named undescribed taxa. This was undertaken in order to adhere to scientific protocol and limit the use of unpublished names. A list of taxa with modified names is presented in **Appendix A**.

Table 2: Taxonomists involved in the identification of stygal groups from the LMUP.

Taxonomist	Institution/s	Group
Dr Tomislav Karanovic (TK)	University of Tasmania Hanyang University, Korea	Copepoda
Dr Ivana Karanovic (IK)	University of Tasmania Hamburg Zoologisches Museum	Ostracoda
Michael Scanlon (MDS)	Outback Ecology Bennelongia Pty Ltd, Western Australia	Oligochaeta
Jane McRae (JMM)	Bennelongia Pty Ltd, Western Australia	Isopoda, Amphipoda

The Export License (*Wildlife Conservation Act 1950*, Regulation 18) ES002062 was obtained for the transport of specimens to taxonomists interstate. Material which required specialist identification outside of Australia (following the relocation of the taxonomists) was lodged with the Western Australian Museum (WAM) and forwarded to the relevant institutions.

3. RESULTS AND DISCUSSION

3.1 Groundwater quality

Basic groundwater quality measured from bores within the LMUP project indicated pH ranged from 6.93 to 8.91, classified as circumneutral (6.5-7.5) to alkaline (>7.5), *sensu* Foged (1978). Groundwater salinity ranged from freshwater (1.3 mS/cm) to hypersaline (176.4 mS/cm), *sensu* Hammer (1986), increasing towards the Lake Maitland playa. Temperature showed typical seasonal variation (ranging from 16.5 to 32.4 °C) and dissolved oxygen ranged from extremely anoxic (0.01 ppm) to highly oxygenated (20 ppm). The main parameters likely to restrict stygofauna distribution within groundwaters are pH and salinity. Some ostracods have been documented from pH as low as 4.40 (Reeves *et al.* 2007), however the most diverse stygal communities inhabit calcareous environments between pH 7.2 and 8.2 (Humphreys 2008). For salinity, groundwaters that exceed 80 mS/cm are unlikely to support significant stygal communities, although recent work has suggested that some taxa have higher tolerance limits (Outback Ecology unpublished data). The complete list of water quality data recorded from all sites is provided in **Appendix B-F**.

Table 3: Summary of groundwater quality data from each assessment within the LMUP (EC=electrical conductivity, Temp=temperature, DO=dissolved oxygen, SWL=standing water level)

Date	Range	pH (units)	EC (mS/cm)	Temp (°C)	DO (ppm)	SWL (m)
Jan 2007	min	7.9	1.3	NA	NA	3.8
	max	7.9	7.2	NA	NA	4.6
May 2007	min	6.96	3.174	21.7	10.68	0.8
	max	8.27	176.4	26.5	20	7.6
Dec 2008	min	7.02	2.096	20.8	0.19	1
	max	8.91	169	27.3	4.98	14
Mar 2010	min	6.93	13.13	24.4	0.01	0.95
	max	7.95	172.3	32.4	7.55	5.3
Aug 2010	min	7.15	1.854	16.5	2.43	2.85
	max	8.53	53.2	23.8	6.54	5.2
Overall	min	6.93	1.3	16.5	0.01	0.8
	max	8.91	176.4	32.4	20	14

3.2 Stygofauna

3.2.1 Overview

Over 600 stygal or putative stygal specimens were collected from the groundwaters of LMUP area between January 2007 and August 2010 (**Appendix G**). The specimens belonged to 29 taxa, including putative stygofauna, stygophiles (temporary groundwater taxa) and stygobites (obligate groundwater taxa). Arthropods, specifically stygal crustaceans (**Appendix H**, **Plate 1**), account for the majority of taxa (21), with putative stygofauna including annelids, nematodes and rotifers contributing to a lesser extent.

3.2.2 Distribution

Of the 29 stygal and putative stygal taxa recorded from Lake Maitland, 13 (including rotifers and nematodes) are known to occur in groundwaters outside the LMUP area and are unlikely to be threatened by the mining proposal. The distribution of the remaining taxa appears to be more restricted, suggesting that the groundwaters of Lake Maitland contain at least some taxa of conservation significance. Consistent with this, the stygofauna of the LMUP area, in particular the calcrete, are encompassed within the Barwidgee calcrete priority 1 ecological community, as assigned by the Department of Environment and Conservation (Department of Environment and Conservation 2010).

Given that the extent of the impact area has not yet been fully defined (specifically the drawdown zone), the level of risk to potentially restricted taxa from the mining proposal cannot be thoroughly assessed. The following should therefore be regarded as a preliminary overview of taxa which are currently known from the LMUP area.

Based on the surveys to date, five malacostracan taxa, seven maxillopod taxa and three clitellate taxa have been identified as restricted to the LMUP area. The majority of malacostracan taxa; Chiltoniidae sp. OES1 (Amphipoda), *Atopobathynella* sp. OES6 (Bathynellacea) and *Haloniscus* sp. OES2 (Isopoda), were collected from the calcrete aquifer between the north-western and south-western arms of the lake. It is probable that their distribution does not extend beyond this aquifer, and therefore these taxa may be of conservation significance. Molecular studies of amphipods, isopods and bathynellaceans from various calcretes in the Yilgarn region have shown that some species are restricted to single calcrete bodies (Cooper *et al.* 2007, Cooper *et al.* 2008, Guzik *et al.* 2008).

The remaining undescribed malacostracans *Haloniscus* sp. OES1 (Isopoda) and Bathynellidae sp. OES1 (Bathynellacea) were recorded from playa sites and Two Jack Well to the east. The conservation status of these taxa is currently unknown.

Over half of the potentially restricted maxillopods (copepods) were collected from the calcrete aquifer and the edge of the playa (near the south-western claypans). It is however likely that at least some of these taxa are distributed outside the LMUP area. At least seven of the copepod taxa recorded from the groundwaters of the LMUP area have been recorded from other areas of the Yilgarn. A primary example of this is *Ameiropsyllus* sp. TK1, an undescribed species which has also been collected from groundwaters near Lake Way (T. Karanovic *pers. comm.* 2007). In addition, potentially restricted taxa including *Schizopera* sp. TK1, *Schizopera* TK5 and *Schizopera* sp. TK6, are considered to be morphologically similar to specimens from Lake Way, and with further studies, could prove to be the same species.

Based on these factors, it appears probable that the risk to stygal copepods from the mining proposal will be lower than that of malacostracans. There does however remain the possibility that some of the copepod taxa are restricted to the LMUP area and therefore are of conservation significance. The level of risk to these taxa will be governed by further refinement of mining impacts.

The clitellate (oligochaete) taxa which are potentially restricted to the LMUP area include Enchytraeidae sp. OES1, Naididae sp. OES1 and Naididae OES2. Of these, Enchytraeidae sp. OES1 is located within the calcrete aquifer between the north-western and south-western arms of the lake playa while the two naidid taxa were collected from the borefield area to the north and lake playa sites respectively. Oligochaetes are known to inhabit a range of aquatic and terrestrial environments (Moore 2008), making the habitat preferences and conservation significance of these undescribed taxa difficult to discern.

Table 4: Distribution of stygofauna (Arthropoda: Malacostraca) collected from the Lake Maitland Project area between January 2007 and August 2010. Orange shading represents specimens which are yet to be identified.

Phylum	Class	Order	Lowest Taxonomic Identification	Bore Code	Distribution and Comments
Arthropoda	Malacostraca	Amphipoda	Chiltoniidae sp. OES1	Little Well, LMST002, LMST008, LMST010	An undescribed taxon. Does not key to either *Austrochiltonia* or *Phreatochiltonia* [a], the two genera currently known from Australian waters [b.] However, is closer to the widespread genus *Austrochiltonia* [a.]
			Chiltoniidae*	EH01, Little Well, LMST002	Immature and could not be identified further. Likely to belong to Chiltoniidae sp. OES1.
		Bathynellacea	*Atopobathynella* sp. OES6	Little Well	An undecribed species. Genus is widely distributed in Western Australia, recorded from calcrete aquifers of the Yilgarn region and coastal plain aquifers of the Gascoyne and Pilbara regions [c.]
			Atopobathynella sp.*	Little Well, LMAC0423	Immature and/or damaged. Could not be identified further.
			Bathynellidae sp. OES1	Two Jacks Well	An undescribed taxon. Family has been documented from groundwaters in the Pilbara [d], Yilgarn [e], south-west [f] and south coast of Western Australia [g.]
			Bathynellidae*	Two Jacks Well	Immature and could not be identified further. Likely to belong to Bathynellidae sp. OES1.
		Isopoda	*Haloniscus* sp. OES1	LMAC0448, LMAC0545, LMAC0012, LMAC0352	Undescribed oniscoid isopod in the well-known salt water genus *Haloniscus* (Family Scyphacidae). Species comes out at the stylifera/tormentosa couplet in Taiti and Humphreys' (2001) key but does not fit either species [a.]
			Haloniscus sp. OES2	LMST008	Undescribed oniscoid isopod. Separated from *Haloniscus* sp. OES1 based on morphological differences.

a. (J. McRae pers. comm. 2007), b. (King 2009), c (Cho *et al.* 2006), d (Eberhard *et al.* 2004), e (De Laurentiis *et al.* 2001), f (Bennelongia 2008), g. (Rockwater 2006).

* denotes taxa which have been omitted from the final tally of stygal taxa based on immaturity or poor condition.

Table 5: Distribution of stygofauna (Arthropoda: Maxillopoda) collected from the Lake Maitland Project area between January 2007 and August 2010 (* denotes taxa omitted from the final tally of stygal taxa). Orange shading represents specimens which are yet to be identified.

Phylum	Class	Order	Lowest Taxonomic Identification	Bore Code	Distribution and Comments
Arthropoda	Maxillopoda	Cyclopoida	Cyclopidae sp.*	LMAC0012	Specimen misplaced during examination. Based on distribution, considered likely to be *Halicyclops eberhardi.*
			Dussartcyclops uniarticulatus	6 Mile Bore	Small stygobitic species recorded from several localities within the Yilgarn including Depot Springs and Lake Austin [h.] Formerly known as *Goniocyclops uniarticulatus* [i.]
			Halicyclops eberhardi	Little Well, LMAC0012, LMSC021	Previously thought to be widely distributed in groundwaters of the Yilgarn region. Molecular work in a calcrete near Lake Maitland now suggests the presence of more than one cryptic species. As a result, the species is currently considered to be a species complex [i.]
			Halicyclops sp. TK1	EH01	A very large undescribed species. Aside from the size, morphologically identical to *Halicyclops eberhardi* . Stygobitic [i.]
			Halicyclops sp. TK2	EH01, Little Well, LMST004, LMST006, LMST008, LMST014	A very small undescribed species (a sister species to Halicyclops sp. TK1). Provisionally named *Halicyclops 'microeberhardi'* by TK. Differs from *Halicyclops eberhardi* in size. Stygobitic [i.]
			Mesocyclops brooksi	6 Mile Bore	A stygophilic species recorded from more than 10 localities in the Yilgarn region [h.] Also known from the Pilbara region [j.]
			Microcyclops varicans	6 Mile Bore	Widespread in surface waters but also inhabits subterranean waters and is therefore considered stygophilic [k.]

h. (Karanovic 2004), i. (T. Karanovic pers. comm. 2010), j (Karanovic 2006).

* denotes taxa which have been omitted from the final tally of stygal taxa based on immaturity or poor condition.

Table 6: Distribution of stygofauna (Arthropoda: Maxillopoda continued) collected from the Lake Maitland Project area between January 2007 and August 2010 (* denotes taxa omitted from the final tally of stygal taxa). Orange shading represents specimens yet to be identified.

Phylum	Class	Order	Lowest Taxonomic Identification	Bore Code	Distribution and Comments
Arthropoda	Maxillopoda	Harpacticoida	Harpacticoida*	Little Well	Identification pending
			Ameiropsyllus sp. TK1	LMAC0448	A singleton. First record of the genus *Ameiropsyllus* in Australia and third species ever from this genus. It is also the first non-marine representative. Additional material (at least one female) of this species is needed to verify its generic status. This taxon has also been recorded from groundwaters near Lake Way [l.]
			Australocamptus similis	#15 Well	Has previously been recorded from groundwaters in the Wiluna area of the Yilgarn region [h.] Potentially stygophilic [i.]
			Nitokra lacustris pacifica	EH01, Little Well, LMAC0423, LMAC0545	A stygophilic taxon which occasionally occurs in groundwaters of the Yilgarn region [h.]
			Nitokra sp. TK3	EH01	Morphologically similar to *Nitokra* sp. TK1 from groundwaters near Lake Way. Stygobitic [i.]
			Schizopera sp. TK1	EH01, LMAC0352, LMAC0448	An undescribed stygobitic taxa. Considered likely to be the same taxon as a specimen recorded from groundwaters near Lake Way. However, more material from both locations would be required for further study [l.]
			Schizopera sp. TK5	Little Well	An undescribed stygobitic taxa. Morphologically similar to specimens collected from groundwaters near Lake Way. Difficult to determine whether they are the same species. Further study would be required. [i.]
			Schizopera sp. TK6	Little Well, LMST006, LMST011	Initially identified as *Schizopera weelumurra.* Reclassified after additional material was collected. Provisionally named by TK as *Schizopera 'dimorpha'.* Morphologically similar specimens have been identified from groundwaters near Lake Way. Further study would be required to determine whether they are the same species [i.]
			Schizopera sp. TK8	LMST012	A singleton (one specimen collected). Undescribed, considered likely to be a new species. Additional material would be required for confirmation [k.]

h. (Karanovic 2004), i. (T. Karanovic pers. comm. 2010), k. (T. Karanovic pers. comm. 2011), l. (T. Karanovic pers. comm. 2007).

* denotes taxa which have been omitted from the final tally of stygal taxa based on immaturity or poor condition.

Table 7: Distribution of stygofauna (Arthropoda; Annelida; Nematoda and Rotifera) collected from the Lake Maitland Project area between January 2007 and August 2010 (* denotes taxa omitted from the final tally of stygal taxa). Orange shading represents specimens which are yet to be identified.

Phylum	Class	Order	Lowest Taxonomic Identification	Bore Code	Distribution and Comments
Arthropoda	Ostracoda	Podocopida	*Candonopsis* nr *dani*	Little Well, LMST006	Previously identified as *Candonopsis dani*. Morphological variation between the collected material and the original description were noted and may result in revision of the species [m.]
			Sarscypridopsis ochracea	6 Mile Bore, Eclipse Well	A common surface water species which is often recorded from bores and wells in the Yilgarn region [n.]
Annelida	Clitellata	Tubificida	Enchytraeidae sp. OES1	Little Well	Family known to occur in groundwaters of the Pilbara and Yilgarn regions [d,o.]
			Enchytraeus Pilbara sp. 2 (PSS)	Two Jacks Well	First identified from groundwaters of the Pilbara Region [p.]
			Enchytraeidae*	#15 Well	Could not be identified further.
			Naididae sp. OES1	6 Mile Bore	Members of this family has been documented from groundwaters in the Pilbara and Yilgarn regions [d,o,q.]
			Naididae sp. OES2	LMAC0334, LMAC0448	
			Naididae morphospecies 1/1A (PSS)	Little Well	A singleton. Formerly known as Tubificidae morphospecies 1/1A (DEC). First recorded from groundwaters of the Pilbara region [p.]
			Naididae stygo type 5 (PSS)	LMAC0334	An immature singleton. Formerly known as Tubificidae stygo type 5 (DEC). Also present in groundwaters within the Pilbara region [p.]
Nematoda			Nematoda	LMAC0011, Two Jacks Well	Guidance Statement 54a (Technical appendix to EPA Guidance Statement No. 54) [r] highlights these as groups for which species level identification is not expected.
Rotifera			Rotifera	BH09	

d (Eberhard *et al.* 2004), m. (I. Karanovic pers. comm. 2010), n. (I. Karanovic pers. comm. 2008), o. (Outback Ecology unpublished data), p. (DEC unpublished data), q. (Pinder *et al.* 2006), r. (EPA 2007). * denotes taxa which have been omitted from the final tally of stygal taxa based on immaturity or poor condition.

FURTHER WORK

Once the extent of the impact area for the LMUP has been defined, a thorough analysis of the risk to stygofauna, specifically restricted taxa, can be undertaken. Sampling of additional reference sites may be required to determine their occurrence outside the impact zone (particularly within the calcrete tongue and borefield areas). Genetic analyses may also be warranted following refinement of drawdown and developmental impacts associated with the LMUP. Molecular analyses are being increasingly used in conjunction with morphological investigations to provide a greater understanding of stygal distribution patterns and can provide greater clarity in relation to restricted taxa.

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Appendix A

Summary of modified morphospecies names

Previous Morphospecies or Provisional Name	Outback Ecology Morphospecies Name
Ameiropsyllus sp. 1	*Ameiropsyllus* sp. TK1
Ceinidae/Chiltoniidae sp. 1 (OES)	Chiltoniidae sp. OES1
Haloniscus sp. 1 OES	*Haloniscus* sp. OES1
Halicyclops 'macroeberhardi'	*Halicyclops* sp. TK1
Halicyclops 'microeberhardi'	*Halicyclops* sp. TK2
Nitokra cf. 'megaregis'	*Nitokra* sp. TK3
Schizopera sp. 1	*Schizopera* sp. TK1
Schizopera cf. sp. 2	*Schizopera* sp. TK5
Schizopera 'dimorpha'	*Schizopera* sp. TK6
Schizopera sp. 3	*Schizopera* sp. TK8

Appendix B

Water quality measurements, January 2007

Bore	pH	EC (mS/cm)	Temp (°C)	DO (ppm)	SWL (m)
LMAC0012					
#15 Well	7.90	1.30	-	-	3.8
Little Well					
LMACW01	7.90	7.20	-	-	4.6

Appendix C

Water quality measurements, May 2007

Bore	pH	EC (mS/cm)	Temp (°C)	DO (ppm)	SWL (m)
LMAC0008	7.73	51.20	23.9	19.85	1.80
LMAC0009	7.52	66.50	25.3	17.25	1.80
LMAC0010	7.55	76.40	25.9	15.85	1.50
LMAC0011	7.59	60.60	25.7	16.87	2.18
LMAC0012	7.53	80.00	25.6	15.41	1.58
LMAC0160	7.60	45.30	25.6	15.49	3.55
LMAC0179	7.63	103.60	22.8	20.00	1.18
LMAC0212	6.96	176.40	26.5	17.90	0.95
LMAC0266	7.11	157.20	24.9	18.43	0.80
LMAC0312	7.11	150.20	25.1	15.82	1.36
LMAC0334	7.13	150.00	24.7	19.76	1.00
LMAC0352	7.31	129.60	25.4	16.54	1.16
LMAC0448	7.30	132.30	23.8	16.04	1.30
LMAC0527	7.39	125.70	25.9	15.10	1.70
LMAC0541	7.28	105.20	25.5	15.88	1.57
Eclipse Well	8.18	3.17	21.7	16.75	2.72
Little Well	7.54	12.69	24.5	19.52	3.87
Salt Well	8.27	8.20	22.4	17.05	7.60
Two Jacks Well	7.93	7.39	24.7	10.68	3.85

Appendix D

Water quality measurements, December 2008

Bore	pH	EC (mS/cm)	Temp (°C)	DO (ppm)	SWL (m)
LMAC0009	7.80	79.60	25.40	4.84	2.03
LMAC0011	8.19	77.00	22.20	4.73	1.90
LMAC0012	7.88	94.50	22.70	2.57	1.80
LMAC0147	7.79	104.40	22.40	4.24	2.00
LMAC0160	8.91	54.60	26.30	3.88	3.50
LMAC0168	8.12	60.30	22.80	3.55	2.50
LMAC0179	7.89	106.20	25.20	4.02	1.45
LMAC0212	7.13	169.00	25.80	3.61	1.05
LMAC0266	7.02	143.00	25.20	2.37	1.00
LMAC0291	8.12	66.60	26.00	3.56	3.50
LMAC0312	7.17	141.90	26.20	1.92	2.62
LMAC0334	7.10	139.40	25.50	1.97	1.05
LMAC0352	7.48	128.10	25.30	2.86	1.38
LMAC0399	8.10	61.20	26.70	3.09	2.50
LMAC0401	7.79	65.00	25.20	2.45	1.50
LMAC0406	8.08	46.30	27.30	4.02	2.50
LMAC0423	8.26	61.90	23.30	3.28	1.50
LMAC0448	7.39	122.50	24.30	2.56	1.50
LMAC0505	8.17	43.50	24.40	1.64	4.50
LMAC0545	7.69	75.50	25.10	4.98	1.50
LMSC-021	7.45	94.60	23.50	1.02	1.64
LMSC-030	7.18	146.40	25.40	2.42	1.34
6 Mile Bore	8.17	2.10	24.50	1.83	5.57
BJP5	8.74	4.09	26.00	0.86	14.00
Eclipse Well	8.38	4.18	20.80	1.51	2.50
Little Well	7.45	12.42	25.80	4.27	4.51
LMACW1	7.73	3.70	26.90	0.19	4.82
Northern Control Bore	8.23	3.70	26.70	4.02	5.10
Salt Well	8.36	10.26	21.40	1.82	4.50
Two Jacks Well	7.62	7.73	27.30	1.30	4.00

Appendix E

Water quality measurements, March 2010

Bore	pH	EC (mS/cm)	Temp (°C)	DO (ppm)	SWL (m)
EH01	6.93	105.9	25.8	7.55	2.3
EH02	7.9	114	29	NA	2.12
EH03	NA	58.9	27.9	NA	5.3
EH04	7.95	112.3	32.4	NA	0.95
EH05	7.21	157.9	29.2	NA	1.42
EH06	7.51	68.5	26.1	0.01	2.52
BH01	7.35	137.8	28.4	NA	2.24
BH02	7.7	114.6	28.5	NA	2.16
BH03	7.1	138.5	27	NA	2.21
BH04	7.08	172.3	28.2	NA	1.62
BH05	7.61	138	29.7	NA	1.81
BH06	7.55	114.6	29.6	NA	1.84
BH08	7.51	116.3	25.6	NA	2.36
BH09	7.33	101	28.3	0.05	2.18
BH10	7.62	74.8	28.5	NA	3.7
BH11	7.32	105.7	27.4	0.01	2.34
LMAC0423	7.63	72.2	25.1	NA	2.32
LMAC0448	7.23	141.4	24.4	0.01	1.61
Little Well	NA	13.13	24.4	0.01	4.67

Appendix F

Water quality measurements, August 2010

Bore	pH	EC (mS/cm)	Temp (°C)	DO (ppm)	SWL (m)
6 Mile Bore	8.53	1.854	16.5	6.35	5.2
Little Well	7.41	12.37	21.9	5.04	4.26
Northern Control Bore	8.38	3.96	18.9	6.54	4.13
LMACW1	7.92	3.76	20.5	2.94	4.81
LMST001	7.27	49.2	23.6	2.43	4.08
LMST002	7.59	35.3	22.2	4.04	3.78
LMST003	7.41	53.2	22.1	3.83	2.85
LMST004	7.49	39.1	22.1	4.98	4.3
LMST005	7.33	44.4	22.5	3.4	3.47
LMST006	7.59	35.4	22.2	5.02	3.87
LMST011	7.3	33.4	22.7	3.34	4.13
LMST008	7.26	20.09	23.8	4.85	4.34
LMST010	7.15	29.3	23	4.15	3.73
LMST007	7.58	37.7	20.8	4.71	3.74
LMST012	7.3	24.9	22.4	4.52	4.01
LMST014	7.3	31.5	23.7	4.82	4.3

Appendix G

Stygofauna data recorded from the Lake Maitland sites

Resource Sites

Bore Code	Eastings (UTM WGS 84: 51 J)	Northings (UTM WGS 84: 51 J)	Classification	Taxa	No. of Individuals
BH01	307495	6996779	Resource	NIL	0
BH02	309414	6995393	Resource	NIL	0
BH03	311495	6995979	Resource	NIL	0
BH04	311594	6994783	Resource	NIL	0
BH05	311397	6994172	Resource	NIL	0
BH06	310886	6992779	Resource	NIL	0
BH08	309993	6992230	Resource	NIL	0
BH09	309994	6991580	Resource	Rotifera	1
BH11	309948	6990980	Resource	NIL	0
EH01	308397	6991573	Resource	Chiltoniidae	3
				Halicyclops sp. TK1	12
				Halicyclops sp. TK2	6
				Nitokra lacustris pacifica	3
				Nitokra sp. TK3	15
				Schizopera sp. TK1	2
EH02	310475	6991789	Resource	NIL	0
EH03	309004	6993186	Resource	NIL	0
EH04	311393	6993367	Resource	NIL	0
EH05	310600	6994777	Resource	NIL	0
EH06	308500	6995972	Resource	NIL	0
LMAC0008	309784	6991975	Resource	NIL	0
LMAC0009	309844	6991983	Resource	NIL	0
LMAC0010	309897	6991980	Resource	NIL	0
LMAC0011	309945	6991984	Resource	Nematoda	1
LMAC0012	309998	6991982	Resource	Cyclopidae sp.	1
	309998	6991982	Resource	*Halicyclops eberhardi*	1
	309998	6991982	Resource	*Haloniscus* sp. OES1	2
LMAC0147	309894	6992778	Resource	NIL	0
LMAC0160	308902	6993181	Resource	NIL	0
LMAC0168	309445	6992382	Resource	NIL	0
LMAC0179	310547	6992379	Resource	NIL	0
LMAC0212	311601	6993184	Resource	NIL	0
LMAC0266	311798	6994380	Resource	NIL	0
LMAC0312	310999	6994782	Resource	NIL	0
LMAC0334	311703	6995182	Resource	Naididae stygo type 5 (PSS)	1
				Naididae sp. OES2	18
LMAC0352	309905	6995181	Resource	*Haloniscus* sp. OES1	2
				Schizopera sp. TK1	4
LMAC0423	308501	6995978	Resource	*Atopobathynella* sp.	1
				Nitokra lacustris pacifica	1
LMAC0448	307503	6996986	Resource	*Ameiropsyllus* sp. TK1	1
				Haloniscus sp. OES1	2
				Naididae sp. OES2	1
				Schizopera sp. TK1	1
LMAC0505	309008	6993184	Resource	NIL	0
LMAC0527	310603	6993579	Resource	NIL	0
LMSC-021	310480	6991784	Resource	*Halicyclops eberhardi*	1

Calcrete Sites

Bore Code	Eastings (UTM WGS 84: 51 J)	Northings (UTM WGS 84: 51 J)	Classification	Taxa	No. of Individuals
Little Well	302210	6997164	Calcrete tongue	*Atopobathynella* sp.	1
				Atopobathynella sp. OES6	1
				Candonopsis nr *dani*	34
				Chiltoniidae	39
				Chiltoniidae sp. OES1	37
				Enchytraeidae sp. OES1	12
				Halicyclops eberhardi	92
				Halicyclops sp. TK2	131
				Harpacticoida	14
				Naididae morphospecies 1/1A	1
				Nitokra lacustris pacifica	5
				Schizopera sp. TK5	3
				Schizopera sp. TK6	32
LMST001	307400	6993767	Calcrete tongue	NIL	0
LMST002	308213	6993778	Calcrete tongue	Chiltoniidae	5
	308213	6993778	Calcrete tongue	Chiltoniidae sp. OES1	3
LMST003	309812	6993785	Calcrete tongue	NIL	0
LMST004	307911	6992673	Calcrete tongue	*Halicyclops* sp. TK2	4
LMST005	307109	6992680	Calcrete tongue	NIL	0
LMST006	308186	6994776	Calcrete tongue	*Candonopsis* nr *dani*	2
	308186	6994776	Calcrete tongue	*Halicyclops* sp. TK2	39
	308186	6994776	Calcrete tongue	*Schizopera* sp. TK6	5
LMST007	307909	6995780	Calcrete tongue	NIL	0
LMST008	305115	6996771	Calcrete tongue	Chiltoniidae sp. OES1	1
	305115	6996771	Calcrete tongue	*Halicyclops* sp. TK2	3
	305115	6996771	Calcrete tongue	*Haloniscus* sp. OES2	1
LMST010	306324	6995800	Calcrete tongue	Chiltoniidae sp. OES1	1
LMST011	307122	6995775	Calcrete tongue	*Schizopera* sp. TK6	1
LMST012	305413	6994778	Calcrete tongue	*Schizopera* sp. TK8	1
LMST014	306610	6993773	Calcrete tongue	*Halicyclops* sp. TK2	7

Regional and Delta Sites

Bore Code	Eastings (UTM WGS 84: 51 J)	Northings (UTM WGS 84: 51 J)	Classification	Taxa	No. of Individuals
Northern Control Bore	313864	7002434	Northern regional	NIL	0
LMACW1	314858	7002470	Northern regional	NIL	0
#15 Well	312544	7003705	Northern regional	*Australocamptus similis*	5
	312544	7003705	Northern regional	Enchytraeidae	3
6 Mile Bore	307741	7008070	Northern regional	*Goniocyclops uniarticulatus*	2
	307741	7008070	Northern regional	*Mesocyclops brooksi*	5
	307741	7008070	Northern regional	*Sarscypridopsis ochracea*	2
	307740	7008070	Northern regional	*Microcyclops varicans*	3
	307740	7008070	Northern regional	Naididae sp. OES1	2
Salt Well	307413	6984800	Southern regional	NIL	0
Two Jacks Well	314571	6990115	Southern regional	*Enchytraeus* Pilbara sp. 2 (PSS)	34
	314571	6990115	Southern regional	Bathynellidae	1
	314571	6990115	Southern regional	Bathynellidae sp. OES1	2
	314571	6990115	Southern regional	Nematoda	3
BJP5	308581	6981024	Southern regional	NIL	0
Eclipse Well	316616	6975320	Southern regional	*Sarscypridopsis ochracea*	2
BH10	307797	6992281	Delta	NIL	0
LMAC0291	309298	6994580	Delta	NIL	0
LMAC0399	311396	6996779	Delta	NIL	0
LMAC0401	311602	6996780	Delta	NIL	0
LMAC0406	311603	6996980	Delta	NIL	0
LMAC0541	309402	6996780	Delta	NIL	0
LMAC0545	309396	6997182	Delta	*Haloniscus* sp. OES1	5
	309396	6997182	Delta	*Nitokra lacustris pacifica*	1

Appendix H
Stygofauna images

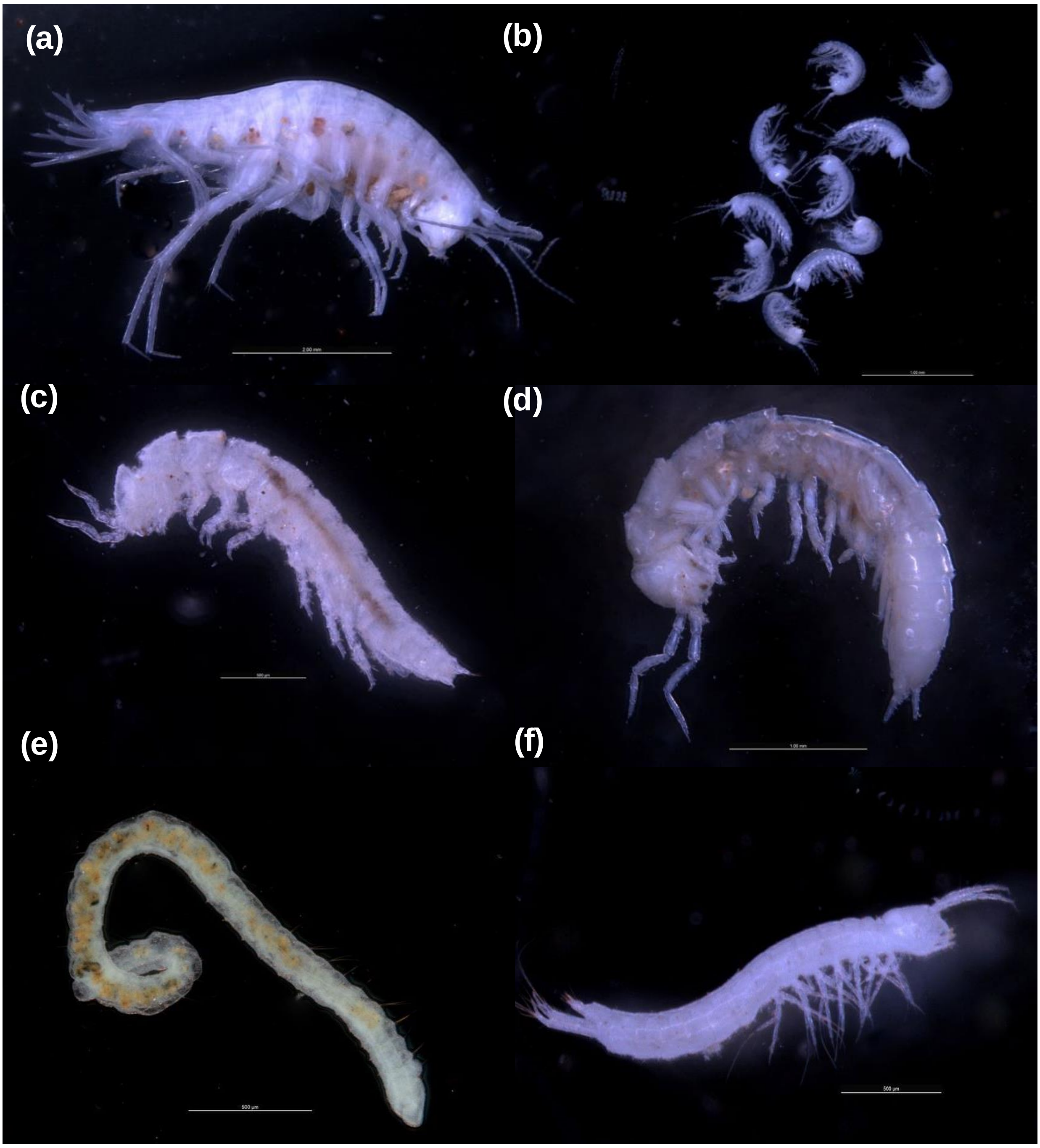

Plate 1: Stygofauna images from the LMUP. (a) amphipod from Little Well, (b) amphipods (multiple specimens) from Little Well, (c) isopod from LMST008, (d) isopod from LMAC448, (e) oligochaete from 6 Mile Bore and (f) syncarid (parabathynellid) from Little Well.